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ABSTRACT

Several hundred thousand people converged on the Kennedy Space Center (Florida) on July 16, 1969, to view the launch of the "Saturn V" rocket that would propel "Apollo 11" to the moon. The engineers and technicians watching their computer screens may secretly have kept their fingers crossed, but at two minutes before launch, a reporter recorded that "idle conversation halted." "We have liftoff," said Mission Control. In another two minutes, there was nothing to see but the blue sky. This lesson, based on the National Register of Historic Places registration files for Cape Canaveral Air Force Station in Florida and for related government properties, can be used in U.S. history, social studies, and geography courses in units on the space program, the Cold War, and its effects on U.S. society, or interdisciplinary units on science and technology. The lesson is divided into eight sections: (1) "About This Lesson"; (2) "Getting Started: Inquiry Question"; (3) "Setting the Stage: Historical Context"; (4) "Locating the Site: Maps" (United States Space Installations; Cape Canaveral and the Kennedy Space Center); (5) "Determining the Facts: Readings" (Preparing the Way; The "Apollo" Hardware; "The 'Eagle' Has Landed"); (6) "Visual Evidence: Images" (Transporting the "Apollo" Space Vehicle to the Launch Site; "Saturn V" Lifting Off, July 16, 1969; Mission Control Center, Diagram and Key; Front Page of the (Washington) "Evening Star," July 21, 1969; View of the Earth from Space); (7) "Putting It All Together: Activities" (Unexpected Benefits from Space Research; A Mission to Mars?; What Price History?); and (8) "Supplementary Resources." (BT)

Teaching with Historic Places

America's Space Program: Exploring a New Frontier

Teaching with Historic Places
National Register of Historic Places
National Park Service
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Washington, D.C. 20240

http://www.cr.nps.gov/nr/twhp/wwwlps/lessons/101space/101space.htm

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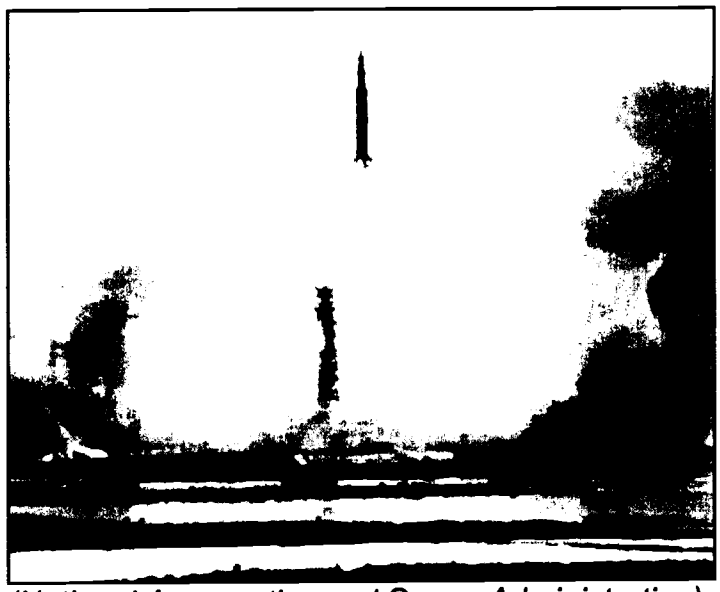
Teaching with Historic Places (TwHP) is a program of the National Register of Historic Places. The National Register is maintained by the National Park Service, U.S. Department of Interior, as the nations's official list of cultural resources significant in American history, architecture, archeology, engineering, and culture. TwHP is sponsored, in part, by the Cultural Resources Training Initiative and Parks as Classrooms programs of the National Park Service. This lesson is one in a series that brings the important stories of historic places into classrooms across the country. For more information, contact Teaching with Historic Places, National Register of Historic places, 1849 C Street, NW, Suite NC400, Washington, D.C. 20240, or visit the program's Web site at www.cr.nps.gov/nr/twhp.

America's Space Program: Exploring a New Frontier



(National Aeronautics and Space Administration)

They came by plane, boat, bus, and auto to Florida's Kennedy Space Center. Generals, members of Congress, governors, mayors, ambassadors, and celebrities filled the VIP grandstand. Journalists from 54 countries waited to send out the news. Several hundred thousand people had converged on the Kennedy Space Center on July 16, 1969, to view the launch of the *Saturn V* rocket that would propel *Apollo 11* to the Moon.

Millions of people all over the world kept their eyes on their television sets waiting for the countdown to begin. The engineers and technicians at the Marshall Space Flight Center in Alabama trusted the *Saturn* rocket they had developed and tested, but may secretly have kept their fingers crossed. The men watching their computer screens at the Mission Control Center at the Manned Spacecraft Center (now the Johnson Space Center) in Texas seemed calm, but their hearts must have been beating a bit faster than normal.

At two minutes before the launch, a reporter recorded that "idle conversation halted. Tedium evaporated. 'We have liftoff,' said Mission Control. People shouted 'Go! Go! Go!,' and whispered 'God bless you.' In another two minutes, there was nothing to see but the blue sky."[1]

[1]*"The Scene at the Cape: Prometheus and a Carnival,"* Time, *July 25, 1969.*

The lesson is based on Cape Canaveral Air Force Station and properties located at the John F. Kennedy Space Center, the George C. Marshall Space Flight Center, and the Lyndon B. Johnson Space Center. These properties are several of the thousands of properties listed in the National Register of Historic Places. Cape Canaveral Air Force Station, and the properties associated with the Marshall Space Flight Center and the Johnson Space Center have been designated National Historic Landmarks.

Table of Contents

About This Lesson

This lesson is based on National Register of Historic Places registration files for Cape Canaveral Air Force Station in Florida, and for properties located at the John F. Kennedy Space Center in Florida, the George C. Marshall Space Flight Center in Alabama, and the Lyndon B. Johnson Space Center in Texas.[1] It also uses materials prepared by the National Aeronautics and Space Administration (NASA). The lesson was written by Rita G. Koman, an education consultant. It was edited by Fay Metcalf, Marilyn Harper, and the Teaching with Historic Places staff. TwHP is sponsored, in part, by the Cultural Resources Training Initiative and Parks as Classrooms programs of the National Park Service. This lesson is one in a series that brings the important stories of historic places into classrooms across the country.

[1]The individual National Register registration forms include:

Kennedy Space Center: "Vehicle Assembly Building," "Launch Control Center," "Headquarters Building," "Operations and Checkout," "Central Instrumentation Facility," "Crawlerway," "Press Site Clock and Flag Pole," "Missile Crawler Transporter Facilities (Crawlers)," and "Launch Complex 39, Pads A and B."

Marshall Space Flight Center: "Redstone Test Stand," "*Saturn V* Dynamic Test Stand," "Propulsion and Structural Test Facility," "Neutral Buoyancy Space Simulator," and "*Saturn V* Space Vehicle."

Johnson Space Center: "Space Environment Simulation Laboratory," and "Apollo Mission Control Center."

Where it fits into the curriculum

Topics: The lesson can be used in American history, social studies, and geography courses in units on the space program, the Cold War and its effects on American society, or interdisciplinary units on science and technology.

Time period: 1960s

See attached Relevant United States History Standards for Grades 5-12

Objectives for students

1) To identify the events that led to the U.S. decision to send a man to the Moon.

2) To examine some of the work necessary to make the Apollo project possible.

3) To describe how widely separated space centers cooperated on the Apollo project.

4) To evaluate arguments for preserving historic sites relating to the space program.

5) To discuss comparable debates about preserving places in their own communities that are associated with recent history.

Materials for students

The materials listed below either can be used directly on the computer or can be printed out, photocopied, and distributed to students. The maps and images appear twice: in a smaller, low-resolution version with associated questions and alone in a larger version.

1) two maps showing locations important to the U.S. space program;

2) three readings about the Apollo project and its impact;

3) one illustration showing the Mission Control Center in Houston.

4) five photographs of the Apollo project and the first manned landing on the Moon.

Visiting the site

John F. Kennedy Space Center http://www-pao.ksc.nasa.gov/
This space center is located east of Orlando in central Florida. From Orlando International Airport, it can be reached by taking State Route 528 (Kennedy Space Center Highway) east and following the signs. Follow State Route 407 until it dead-ends into State Route 405 and turn right. Continue following the signs. From Interstate 95, take exit number 212, if heading north, and exit number 215, if heading south.

George C. Marshall Space Flight Center http://history.msfc.nasa.gov/
The U.S. Space and Rocket Center, in Huntsville, Alabama, is the Marshall Space Flight Center's official visitor center. It is located near the junction of Interstate 565 and Research Boulevard. Take the Sparkman Drive exit and follow the signs. A bus tour of the Space Flight Center is included in the admission fee for the Space and Rocket Center.

Lyndon B. Johnson Space Center **http://www.jsc.nasa.gov/**
This space center is adjacent to Clear Lake at 2101 NASA Road 1, about 20 miles southeast of downtown Houston via Interstate 45.

Much of the hardware of the "space race" is displayed at the U.S. Space and Rocket Center in Huntsville; the Kennedy Space Center; and the Smithsonian Institution's National Air and Space Museum in Washington, D.C.

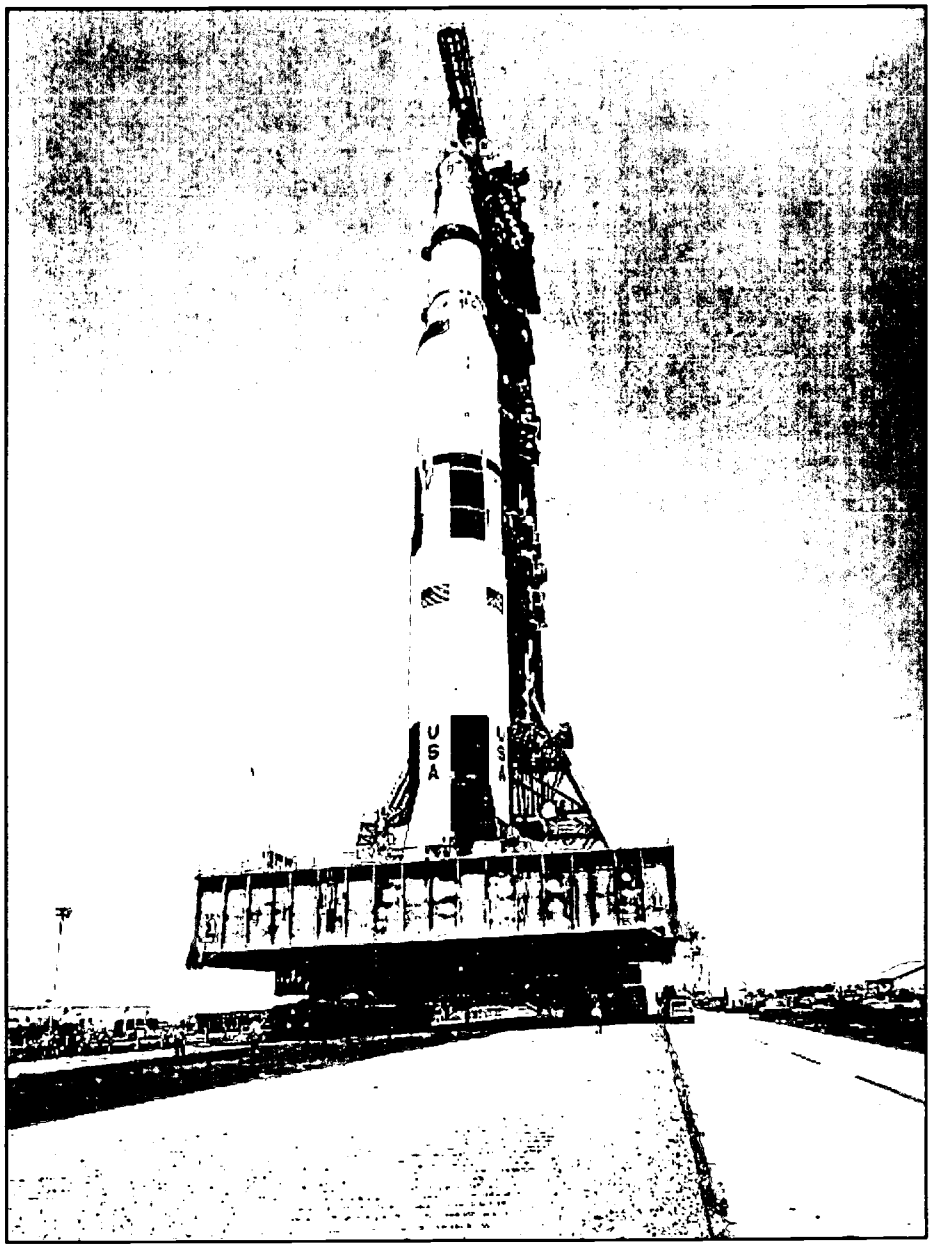
United States History Standards for Grades 5-12
America's Space Program: Exploring a New Frontier
relates to the following National Standards for History:

Era 9: Postwar United States (1945 to early 1970s)

- Standard 1C- The student understands how postwar science augmented the nation's economic strength, transformed daily life, and influenced the world economy.
- Standard 2A- The student understands the international origins and domestic consequences of the Cold War.

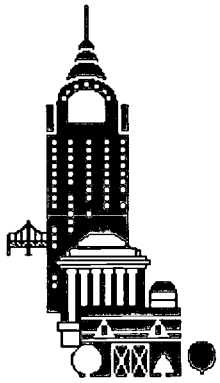
Getting Started

Inquiry Question



(National Aeronautics and Space Administration)

What do you think is happening in this photo?



Teaching with Historic Places

Photo Analysis Worksheet

Step 1:
Examine the photograph for 10 seconds. How would you describe the photograph?

Step 2:
Divide the photograph into quadrants and study each section individually. What details--such as people, objects, activities--do you notice?

Step 3:
What other information--such as time period, location, season, reason photo was taken--can you gather from the photo?

Step 4:
How would you revise your first description of the photo using the information noted in Steps 2 and 3?

Step 5:
What questions do you have about the photograph? How might you find answers to these questions?

Setting the Stage

> If we are to win the battle that is going on around the world between freedom and tyranny, if we are to win the battle for men's minds, the [Soviet Union's] dramatic achievements in space which occurred in recent weeks should have made clear to us all...the impact of this adventure on the minds of men everywhere who are attempting to make a determination of which road they should take.... We go into space because whatever mankind must undertake, free men must fully share.... I believe this Nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to earth.
>
> President John F. Kennedy, May 25, 1961[1]

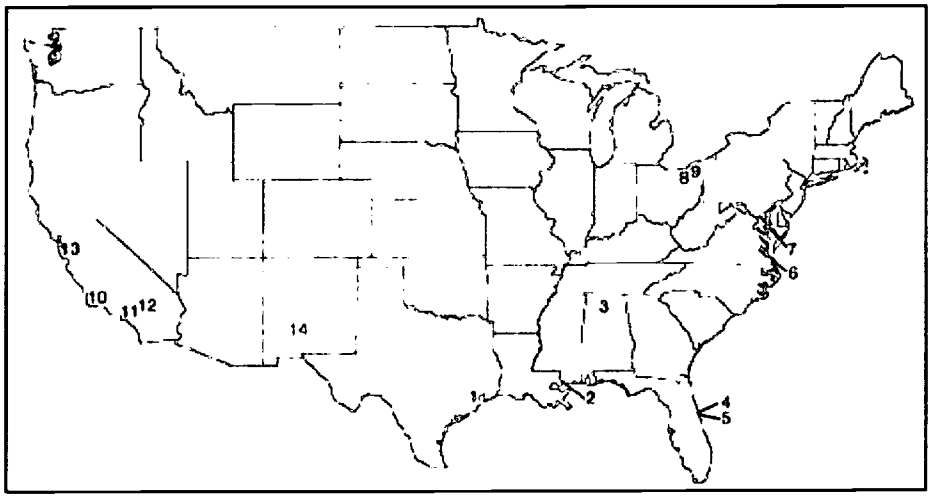
Evidence of man's insatiable curiosity about space can be found throughout human history--in the Greek myth of Icarus trying to fly to the sun, in Galileo's observations of the solar system, and in the first flight of the Wright brothers. The Apollo project to put a man on the Moon was also a product of the 1960s, a period of heightened Cold War tensions. Allegations of a dangerous "missile gap" between the Soviet Union and the United States had been an important element in John F. Kennedy's successful presidential campaign in 1960. In April 1961, Yuri Gagarin, a Soviet cosmonaut, became the first human to fly in space, and the abortive Bay of Pigs invasion, intended to lead to the overthrow of Fidel Castro in Cuba, turned into an embarrassing failure. For the Kennedy administration, the project to put a man on the Moon was a way to recapture the prestige that the nation seemed to have lost.

Closely following the United States' first manned space flight by astronaut Alan Shepard, Kennedy's commitment immediately captured the imagination of the American people. Shepard's short suborbital flight had been part of Project Mercury, underway since 1958 to develop the basic technology and hardware for manned space flight and to investigate man's ability to survive and perform in space. Project Gemini, begun in 1964, formed the link between the Mercury program's short flights and the Apollo program. The Gemini program provided astronauts with experience in returning to the earth from space, in linking between space vehicles, and in "walking" in space without the protection of a spacecraft. A series of unmanned satellites yielded information about the Moon and its surface that was critical to ensuring that the astronauts could survive there. The Apollo project built on the work of its predecessors to carry out President Kennedy's 1961 commitment. Between July 16 and July 24, 1969, as the whole world watched, *Apollo 11* carried three U.S. astronauts to the Moon and returned them safely to earth.

[1]John F. Kennedy, "Urgent National Needs" speech, Congressional Record--House (May 25, 1961), 8276.

Locating the Site

Map 1: United States Space Installations.



Key:

1. **Manned Spacecraft Center (now Johnson Space Center), Texas**
   Space Environment Simulation Laboratory
   Apollo Mission Control Center

2. **National Space Technology Laboratories (now John C. Stennis Space Center), Mississippi/Louisiana**
   Rocket Propulsion Test Complex

3. **Marshall Space Flight Center and the Alabama Space and Rocket Center (now U.S. Space and Rocket Center), Alabama**
   Redstone Test Stand
   Propulsion and Structural Test Facility
   Saturn V Dynamic Test Stand
   Neutral Buoyancy Space Simulator
   Saturn V Space Vehicle

4. **Kennedy Space Center, Florida**
   Space Launch Complex 39

5. **Cape Canaveral AFS, Florida**
   Launch Complexes 5/6, 26, 13, 14, 19, and 34 and the original Mission Control Center

6. **Langley Research Center, Virginia**
   Variable Density Tunnel

Full Scale Tunnel
Eight-foot High Speed Tunnel
Lunar Landing Research Facility
Rendezvous Docking Simulator

7. **Goddard Space Flight Center, Maryland**
   Spacecraft Magnetic Test Facility

8. **Plum Brook Operations Division, Ohio**
   Spacecraft Propulsion Research Facility

9. **Lewis Research Center (now John H. Glenn Research Center at Lewis Field), Ohio**
   Rocket Engine Test Facility
   Zero Gravity Research Facility

10. **Vandenberg AFB, California**
    Space Launch Complex 10

11. **Jet Propulsion Laboratory, California**
    Twenty-five Foot Space Simulator
    Space Flight Operations Facility

12. **Goldstone Deep Space Communications Complex, California**
    Pioneer Deep Space Station

13. **Ames Research Center, California**
    Unitary Plan Wind Tunnel

14. **White Sands Missile Range (now White Sands Test Facility), New Mexico**
    Launch Complex 33

Questions for Map 1

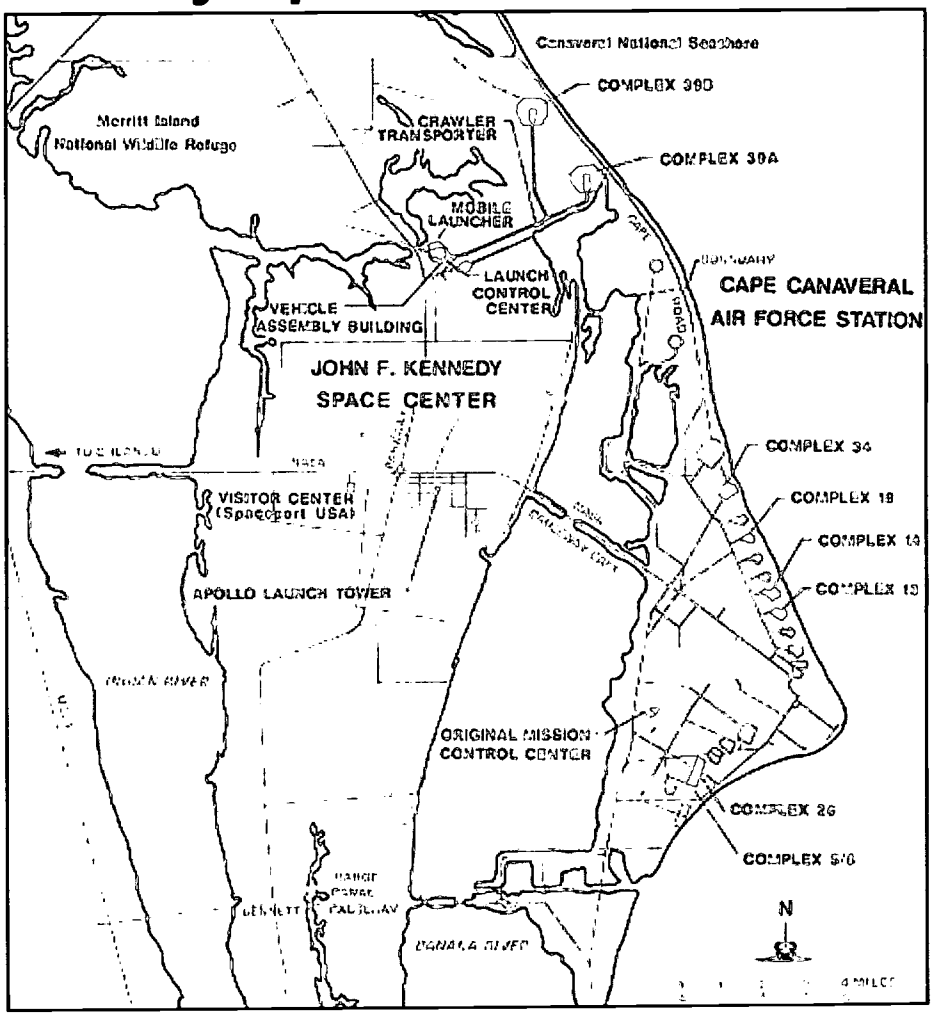
1. This map shows many of the facilities in the United States related to the Apollo program. The items listed under each center identify buildings or installations that represent that space center's specific contribution to the Apollo program. Use the lists to try to determine what role each site played.

2. Why do you think the work for the Apollo program was spread out over so many sites? (Additional information is provided in Reading 1.)

3. Locate the Kennedy and Marshall space centers, as well as the Manned Spacecraft Center (Johnson Space Center). In what states are they located? The Marshall Space Flight Center developed and tested the *Saturn* rocket that powered the *Apollo* spacecraft. The Manned Spacecraft Center (Johnson Space Center) designed the *Apollo* spacecraft and served as the Mission Control Center. The Kennedy Space Center assembled and launched the rockets. How do you think three different places located hundreds of miles apart could cooperate on a single project of this magnitude?

Locating the Site

Map 2: Cape Canaveral and the Kennedy Space Center, Florida.



(National Park Service)

This map shows eight different launch complexes. Fixed launch complexes, usually called launch pads, consisted of a single concrete platform where rockets were assembled, prepared, tested, and launched. Because assembling and launching a rocket takes some time, only a few launches could be made from a fixed complex each year.

Launch Complex 39, Pads A and B are located on Merritt Island, Florida, just north of Cape Canaveral. Both pads were designed to support the concept of mobile launch operations, in which space vehicles are assembled and checked out in the protected environment of the Vehicle Assembly Building, then

transported by a large tracked vehicle called the "crawler-transporter" to the launch pad for final processing and launch. Because one rocket could be assembled while another was in the final stages of preparation for launch, twice as many rockets could be launched from a mobile launch complex as from a fixed one.

Questions for Map 2

1. Find the Kennedy Space Center and Cape Canaveral Air Force Station on Map 1. How would you describe the location?

2. Look at Map 2 and find the eight launch complexes (identified by the word "complex" and a number). Why do you think there are so many? What do the locations have in common? Why might this be the case?

3. Locate complex 39 (a and b), where the *Apollo* moon launches were made. These are mobile launch complexes. What components of the mobile launch operations can you identify on the map? If needed, refer to the caption above.

4. Why do you think NASA chose to use mobile launch complexes for the Apollo program?

Determining the Facts

Reading 1: Preparing the Way

The National Aeronautics and Space Administration (NASA) was established on October 1, 1958, a year after the USSR sent *Sputnik*, the first earth satellite, into space. In 1961, after Soviet cosmonaut Yuri Gagarin became the first man in space, the new agency was assigned responsibility for meeting President Kennedy's commitment to put a man on the Moon by the end of the 1960s. Accomplishing the goal under this strict time constraint was an enormous challenge. By 1966, the 10,000 people employed at the space agency in 1960 had grown to 36,000. NASA's annual budget increased from $500 million in 1960 to a high point of $5.2 billion in 1965, 5.3 percent of the federal budget for that year. Approximately 50 percent of that amount went directly for human spaceflight; the vast majority of that went directly toward Apollo. The project eventually cost $24 billion. According to John Noble Wilford, space correspondent for the *New York Times*, Apollo was the "greatest mobilization of men and resources ever undertaken for a peaceful project of science and exploration."[1]

When NASA began operations in October of 1958, it absorbed into it the earlier National Advisory Committee for Aeronautics intact; its 8,000 employees, an annual budget of $100 million, three major research laboratories--Langley Aeronautical Laboratory, Ames Aeronautical Laboratory, and Lewis Flight Propulsion Laboratory--and two smaller test facilities. It quickly incorporated other organizations into the new agency, notably the space science group of the Naval Research Laboratory in Maryland, the Jet Propulsion Laboratory managed by the California Institute of Technology for the Army, and the Army Ballistic Missile Agency in Huntsville, Alabama.

With the advent of Apollo, the Jet Propulsion Laboratory took over responsibility for developing the necessary guidance and communications technologies and for learning more about the lunar environment. The Marshall Space Flight Center was formed around the Army's ballistic missile team at Redstone Arsenal, which was led by Dr. Wernher von Braun and the other engineers who had developed the first successful rocket, the German *V-2*. Marshall was responsible for building and testing the rockets to power the spacecraft.

NASA created three new facilities specifically to meet the demands of the lunar landing program. In 1962 the agency built the Manned Spacecraft Center (renamed the Lyndon B. Johnson Space Center in 1973), near Houston, Texas, to design the *Apollo* spacecraft and the launch platform for the lunar lander. This center also became the home of NASA's astronauts and the site of mission control. The scientists and engineers in the control room monitored all the details

of the moon flight once the rocket was launched. The Launch Operations Center (renamed the John F. Kennedy Space Center in 1963) at Cape Canaveral on Florida's eastern seacoast was greatly enlarged. All of the *Saturn/Apollo* rockets were assembled in Kennedy's huge 36-story Vehicle Assembly Building and fired from Launch Complex 39. Finally, in October 1961, NASA created the Mississippi Test Facility, renamed the John C. Stennis Space Center in 1988. It was here that the *Saturn* rockets were tested. The cost of this expansion was great, more than $2.2 billion over the decade.

NASA's leaders made an early decision to rely upon outside researchers and technicians to complete the Apollo project. Between 80 and 90 percent of NASA's overall budget in the 1960s went for contracts to purchase goods and services from private industry, research institutions, and universities. Contractor employees working on the program increased more than 10 times, from 36,500 in 1960 to 376,700 in 1965. NASA found that this was both good politics and the best way of getting Apollo done on time. It was also very nearly the only way to harness talent and institutional resources already in existence in the emerging aerospace industry and the country's leading research universities.

More than 500 contractors worked on both large and small aspects of Apollo. For example, the Boeing Company was the prime contractor for the first stage of the *Saturn* rocket, North American Aviation for the second stage, and the Douglas Aircraft Corporation for the third stage. The Rocketdyne Division of North American Aviation was responsible for the rocket engines and International Business Machines for the instruments. These prime contractors, with more than 250 subcontractors, provided millions of parts and components for use in the *Saturn* launch vehicle, all meeting exacting specifications for performance and reliability.

Getting all of these people to work together challenged the men and women responsible for managing the program, whether they worked for the Federal Government, a private industry, or a university. According to Dr. Leonard R. Sayles and Dr. Margaret K. Chandler of the Graduate School of Business at Columbia University, NASA's most significant contribution was "getting an organizationally complex structure, involving a great variety of people doing a great variety of things in many separate locations, to do what you want, when you want it--and while the decision regarding the best route to your objective is still in the process of being made by you and your collaborators."[2]

Questions for Reading 1

1. What event led to the creation of NASA? What event contributed to the decision to send an American to the Moon by the end of the 1960s?

2. What evidence indicates that the Cold War affected the American space program? Why do you think the program was sometimes called "the space race?" (Additional information is included in Setting the Stage.)

3. How many different kinds of work and workers can you identify from this reading?

4. Why was the work for the Apollo program spread out over so many sites? What do you think the advantages and disadvantages might have been if it had been concentrated in one place? Discuss.

5. Why did the project rely so heavily on private industry, research institutions, and universities? What advantages and disadvantages do you think this might have had over using government employees exclusively?

Reading 1 was compiled from "Project Apollo: A Retrospective Analysis" web site, [http://www.hq.nasa.gov/office/pao/History/Apollomon/Apollo.html] *History Office, Office of Policy and Plans, National Aeronautics and Space Administration; "Human Space Flight: A Record of Achievement, 1961-1998"* web site [http://www.hq.nasa.gov/office/pao/History/40thann/humanspf.htm], *History Office, Office of Policy and Plans, National Aeronautics and Space Administration; and from Edward M. Cortright, ed.,* Apollo Expeditions to the Moon *(Washington, D.C.: Scientific and Technical Information Office, National Aeronautics and Space Administration, 1975).*

[1]*John Noble Wilford, "$24 Billion for Big Push to the Moon,"* The New York Times, *Special Apollo Supplement, July 17, 1969, 34.*
[2]*James E. Webb, "A Perspective on Apollo," in Edward M. Cortright, ed.,* Apollo Expeditions to the Moon *(Washington, D.C.: Scientific and Technical Information Office, National Aeronautics and Space Administration, 1975), 17.*

Determining the Facts

Reading 2: The *Apollo* Hardware

James Webb, Administrator of NASA from 1961 to 1968, described the formidable task facing the space agency in 1961:

The *Apollo* requirement was to take off from a point on the surface of the Earth that was traveling 1000 miles per hour as the Earth rotated, to go into orbit at 18,000 miles an hour, to speed up at the proper time to 25,000 miles an hour, to travel to a body in space 240,000 miles distant which was itself traveling 2000 miles per hour relative to the Earth, to go into orbit around this body, and to drop a specialized landing vehicle to its surface. There men were to make observations and measurements, collect specimens, leave instruments that would send back data on what we found, and then repeat much of the outward-bound process to get back home.[1]

The lunar-orbit mode of flying to the Moon was selected only after fierce debate within NASA. It was the simplest of the three methods being considered, both in terms of development and costs, but it was risky. There was no room for error or the crew could not get home. Once the mode of flight was selected, NASA engineers could proceed with building a launch vehicle and creating the basic components of the spacecraft--a habitable crew compartment, a baggage car of some type, and a service module containing propulsion and other expendable systems that could be jettisoned on the trip back.

The Spacecraft

Almost with the announcement of the lunar landing commitment in 1961, NASA technicians began a crash program to develop a reasonable configuration for the trip to lunar orbit and back. What they came up with was a spacecraft that contained a three-person command module capable of sustaining human life for two weeks or more in either Earth or lunar orbit; a service module holding oxygen, maneuvering rockets, fuel cells, life support, and other equipment that could be jettisoned upon reentry to Earth; rockets for slowing the spacecraft to prepare for reentry; and finally a launch escape system that was discarded upon achieving orbit.

Work on the *Apollo* spacecraft began on November 28, 1961, when the prime contract for its development was let to North American Aviation. On January 27, 1967, tragedy struck. Three astronauts--"Gus" Grissom, Edward White, and Roger B. Chaffee--were in the command module training on the launch pad at the Kennedy Space Center. At 6:31 p.m., a fire broke out in the spacecraft. In a flash, flames engulfed the capsule and the astronauts died of asphyxiation.

Shock gripped NASA and the nation during the days that followed. An investigation found that the accident could have been prevented. Changes to the spacecraft were quickly made, and within a little more than a year, it was ready for flight. By October 1968, *Apollo 7* was ready to carry three astronauts into Earth orbit. There, they successfully tested the command/service module and helped restore confidence in the program by proving the spaceworthiness of the basic Apollo vehicle.

The Launch Vehicle

Boosting the *Apollo* vehicles to the Moon and returning them home safely was the job of the giant *Saturn V*. The *Saturn* family of rockets was developed by Wernher von Braun at the Marshall Space Flight Center. At 363 feet tall, the *Saturn V* was the first launch vehicle large enough that it had to be assembled away from the launch pad and transported there.

The *Saturn V* had three stages. The first stage generated 7.5 million pounds of thrust from five massive engines. The extreme heat and shock of firing these engines required new alloys and construction techniques, among the most significant engineering accomplishments of the program. The thunderous sound of the first test of the first stage at Huntsville on April 16, 1965, brought home to many that the Kennedy goal was within grasp. As fuel burned off making the vehicle weigh less, the second stage fired to deliver 1 million pounds of thrust. The third stage burned to send *Apollo* out of Earth orbit and on its way to the Moon.

On December 21, 1968, *Apollo 8* took off with three astronauts aboard--Frank Borman, James A. Lovell, Jr., and William A. Anders--for a historic mission to orbit the Moon. So far Apollo had been all promise; now the delivery was about to begin. The *Apollo 8* crew rode inside the command module, with no lunar lander attached. They were the first astronauts to be launched by the *Saturn V*, which had flown only twice before. The booster worked perfectly, as did the Service Propulsion System (SPS) engines that had been checked out on *Apollo* 7. As it traveled outward the crew focused a portable television camera on the Earth. For the first time humanity saw its home from afar--a tiny, lovely, and fragile "blue marble" hanging in the blackness of space. *Apollo 8* entered lunar orbit on the morning of December 24, 1968. For the next 20 hours the astronauts circled the Moon. They took photographs and scouted future landing sites. They also photographed the first Earthrise as seen from the Moon. *Apollo 8* proved the ability to navigate to and from the Moon, and gave a tremendous boost to the entire Apollo program.

The Lunar Module

The *Apollo* lunar module, or LM, was the first true spacecraft-designed to fly only in a vacuum, with no aerodynamic qualities whatsoever. Launched attached to

the *Apollo* command/service module, it separated in lunar orbit and descended to the Moon with two astronauts inside. At the end of their stay on the surface, the lunar module's ascent stage fired its own rocket to rejoin the command/service module in lunar orbit.

The *Saturn* launch vehicle and the *Apollo* spacecraft were difficult technological challenges, but the lunar module, the third part of the hardware for the Moon landing, represented the most serious problem. Begun a year later than it should have been, the lunar module was consistently behind schedule and over budget. Much of the problem turned on the difficulty of devising two separate components--one for descending to the surface of the Moon and one for returning to the command module. Both engines had to work perfectly or the very real possibility existed that the astronauts would not return home.

The launch vehicle, the spacecraft, and the lunar module were manufactured many hundreds of miles from each other. Transported by specially fitted ocean-going ships and aircraft to the Kennedy Space Center, they came together for the first time in the huge Vehicle Assembly Building. In March 1969 the crew of *Apollo 9* tested the third piece of Apollo hardware--the Lunar Module. For ten days, the astronauts put all three Apollo vehicles through their paces in Earth orbit, undocking and then redocking the lunar lander with the command module, just as they would in lunar orbit. Two of the astronauts performed a space walk, and one checked out the new Apollo spacesuit, the first to have its own life support system rather than being dependent on an umbilical connection to the spacecraft. This mission paved the way for a dress rehearsal for a Moon landing with *Apollo 10* and the subsequent success of *Apollo 11*.

Questions for Reading 2

1. Read James Webb's description of what was involved in landing a man on the Moon. What kinds of things do you think could have gone wrong?

2. Why do you suppose there was so much dispute within NASA about the method of flying to the Moon?

3. Even though the spacecraft that Gus Grissom, Edward White, and Roger Chaffee were supposed to fly never reached space, NASA formally designated it *Apollo 1*. Why do you think they did that?

4. What was the significance of *Apollo 7*?

5. What happened for the first time when *Saturn V* launched *Apollo 8* to orbit the moon? What might that have been like for the people witnessing this historic moment?

6. Which of the three components do you think presented the greatest engineering challenges? Why?

7. Which was the most critical to the success of the Apollo mission?

Reading 2 was compiled from "Project Apollo: A Retrospective Analysis" web site, [http://www.hq.nasa.gov/office/pao/History/Apollomon/Apollo.html] *History Office, Office of Policy and Plans, National Aeronautics and Space Administration; "Human Space Flight: A Record of Achievement, 1961-1998" web site,* [http://www.hq.nasa.gov/office/pao/History/40thann/humanspf.htm] *History Office, Office of Policy and Plans, National Aeronautics and Space Administration; and from Edward M. Cortright, ed.,* Apollo Expeditions to the Moon *(Washington, D.C.: Scientific and Technical Information Office, National Aeronautics and Space Administration, 1975).*

[1]*James E. Webb, "A Perspective on Apollo," in Edward M. Cortright, ed.,* Apollo Expeditions to the Moon *(Washington, D.C.: Scientific and Technical Information Office, National Aeronautics and Space Administration, 1975), 6.*

Determining the Facts

Reading 3: "The *Eagle* Has Landed!"

On July 20, 1969, millions of people fidgeted, held their breath, or prayed. They were waiting for the announcement that the lunar landing craft *Eagle* was safely on the surface of the Moon. The *Eagle* descended from an orbit 70 miles above the surface of the Moon. It had separated from *Columbia*, the "mother" spacecraft, when both were out of sight behind the Moon, cutting off communication with the earth. When the two came back into sight, Michael Collins, commander of *Columbia*, reported, "The *Eagle* has wings." The news that the landing craft was performing as expected brought a sigh of relief, but one of the most dangerous parts of the mission lay ahead.

Guidance computers in the Mission Control Center at the Manned Spacecraft Center (Johnson Space Center) in Houston took the *Eagle* out of orbit and controlled its descent until it was suspended 160 feet from the Moon's surface. The landing site chosen by the computer turned out to be a boulder-strewn crater that could have toppled the *Eagle* and made a later take-off impossible. A signal indicated only 114 seconds of fuel left. If the Eagle could not land within those few seconds, the astronauts would have to abort the mission and return to *Columbia*. It was then that Neil Armstrong, aided by Edwin "Buzz" Aldrin, took control from the computers and manually maneuvered *Eagle* to a landing on the relatively smooth terrain of the Sea of Tranquility. Armstrong coolly reported: "Tranquility Base here. The *Eagle* has landed." There were tears and cheers, and loud applause from the scientists, engineers, and reporters in the control room as Houston responded: "Roger, Tranquility. You got a bunch of boys about to turn blue. We're breathing again. Thanks a lot." The time was 4:17 p.m., EDT.

For the next several hours, the astronauts checked their instruments to make sure the *Eagle* had not been damaged by the landing and prepared it for a quick takeoff, should it have been necessary. The astronauts were supposed to sleep for four hours before they began their walk on the Moon, but they were too excited to relax. They wanted to begin their walk immediately.

At 10:57 p.m. Armstrong opened the door of the *Eagle*, began to climb down the ladder, and opened the pack that protected the television camera that would record the remainder of his climb down to the Moon's surface. When his nine-and-a-half size boots stepped onto the Moon, he uttered words that summarized the nation's feelings about the moon landing: "That's one small step for man; one giant leap for mankind."

Armstrong then set up a television camera to record the astronauts' activities on the Moon. All the while, he chattered away like any tourist in new surroundings;

he snapped photograph after photograph and provided detailed descriptions of his surroundings. Houston had to remind him four times to get back to the high-priority task of gathering lunar soil, so it would be ready to carry back to earth in case the mission had to be aborted. After 30 minutes, Buzz Aldrin came down the ladder, and as soon as he touched the Moon's surface, he paused to jump back to the ladder three times, just to show how easy it was. Then, excited by his weightlessness, he broke into a run.

The two men stayed on the Moon's surface for two and a half hours, gathering 60 pounds of rocks, digging into the Moon's surface for core samples, and setting up scientific equipment. They stopped their work just once, to receive a message from President Richard Nixon who told them, "This certainly has to be the most historic telephone call ever made.... All the people on this earth are truly one in their pride in what you have done." Mission Control in Houston flashed the words of President Kennedy announcing the Apollo commitment on its big screen. Kennedy's words were followed with these: "TASK ACCOMPLISHED, July 1969."[1]

Finally, the men at the Mission Control Center ordered the two men to "head on up the ladder." Armstrong and Aldrin left behind the American flag they had put on the Moon's surface and a plaque reading "We came in peace for all mankind." The plaque was signed by the President and the three astronauts. They left medals and shoulder patches as memorials to Soviet astronauts Yuri Gagarin and Vladimir Komarov, and American astronauts Virgil "Gus" Grissom, Roger Chaffee, and Edward White, all of whom had died while serving in their nations' space programs. (They also brought medals back to earth and presented them to the widows of the Americans.) They left a disk containing statements by Presidents Eisenhower, Kennedy, Johnson, and Nixon, as well as the leaders of 72 other nations, and Pope Paul VI. They also left the bottom part of the lunar module, which they had used as a launch pad, and the backpacks, boots, and other items that had been contaminated with lunar dust. The next day they returned to the *Apollo* capsule and set off back to Earth. They safely splashed down in the Pacific on July 24.

Radios and televisions around the world carried the events of the successful moon landing live. American soldiers in Vietnam stopped to listen despite the war raging around them. The Russians tried to jam Voice of America radio frequencies and buried reports on the moon landing in routine news broadcasts. In most other countries, radio and television stations did their best to make sure that viewers would not miss the moon walk. Streets in some cities were deserted as residents stayed home to watch television coverage. In other countries, television screens were set up out of doors. The worldwide television audience watching the *Apollo* moon landing was the largest in history.

Questions for Reading 3

1. Why do you think the landing craft was controlled from Houston? Why did Armstrong and Aldrin override the computer control and handle the landing themselves?

2. After Armstrong and Aldrin stepped out of the landing craft, how did they react to the huge audience that was watching them on television? What was the first thing each man did? Do you think they should have behaved differently? Why or why not?

3. Why was it so important for someone to remain in the *Columbia* during the walk on the Moon?

4. What did the astronauts leave on the Moon? Why do you think they selected those items?

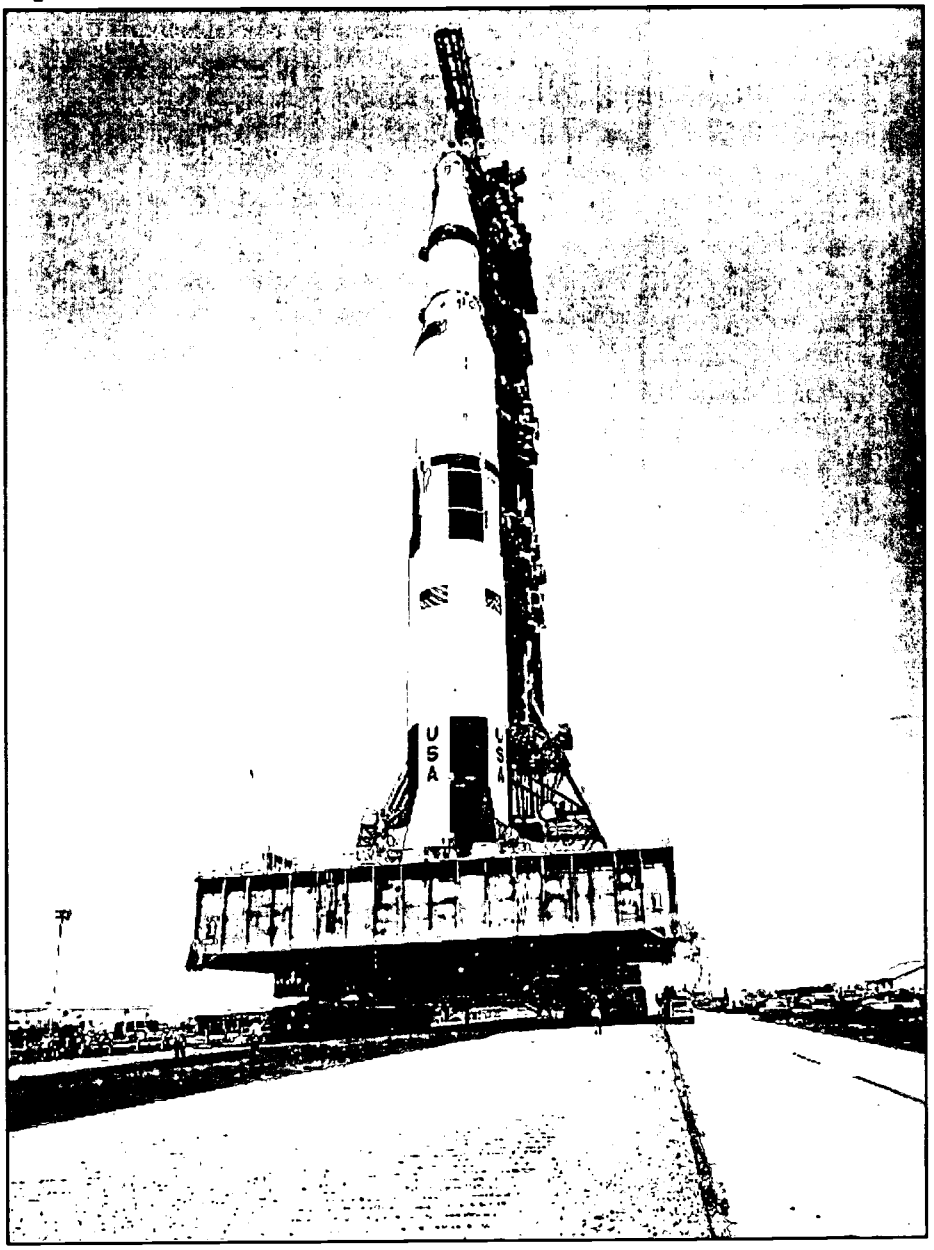
5. Based on the reading, do you think the Apollo program accomplished what President Kennedy hoped it would?

Reading 3 was adapted from articles in the [Washington] Evening Star, *July 21, 1969;* Time, *July 25, 1969, and* Newsweek, *July 28, 1969.*

[1]*"Project Apollo: A Retrospective Analysis" web site* [http://www.hq.nasa.gov/office/pao/History/Apollomon/Apollo.html], *History Office, Office of Policy and Plans, National Aeronautics and Space Administration, 19.*

Visual Evidence

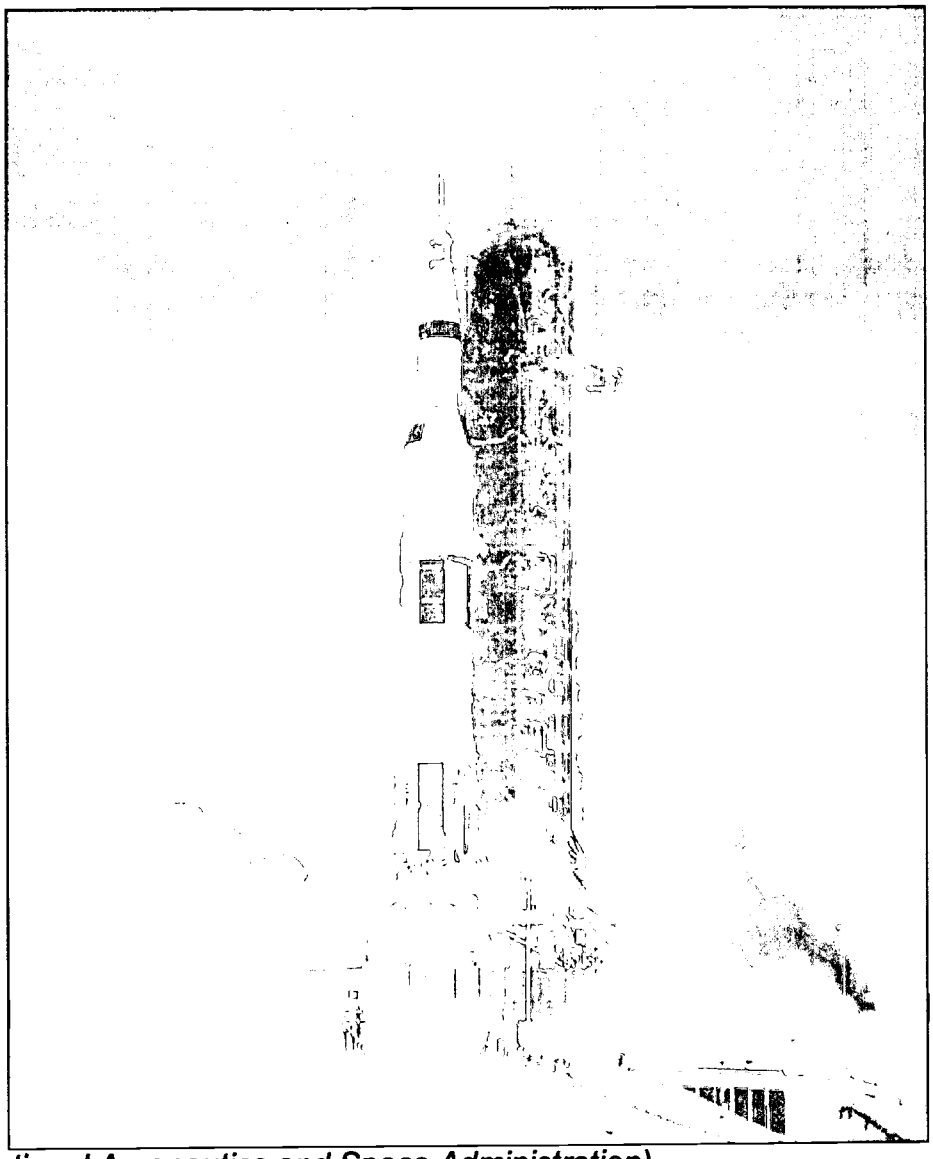
Photo 1: Transporting the *Apollo* space vehicle to the launch site.



(National Aeronautics and Space Administration)

This photo shows the three-part *Saturn V/Apollo* and its mobile launcher moving from the Vehicle Assembly Building to Launch Pad 39A.

Photo 2: *Saturn V* lifting off, July 16, 1969.



(National Aeronautics and Space Administration)

This photo shows the *Saturn V* rocket lifting off from the Kennedy Space Center. The force of the launch shook the ground for many miles around Cape Canaveral.

Questions for Photos 1 and 2

1. Refer back to Map 2 and trace the route of the *Saturn V/Apollo* from the Vehicle Assembly Building to Complex 39A.

2. How is the crawler-transporter moving? It took six hours to complete the six-mile journey to the launch site. Why do you think it moved so slowly?

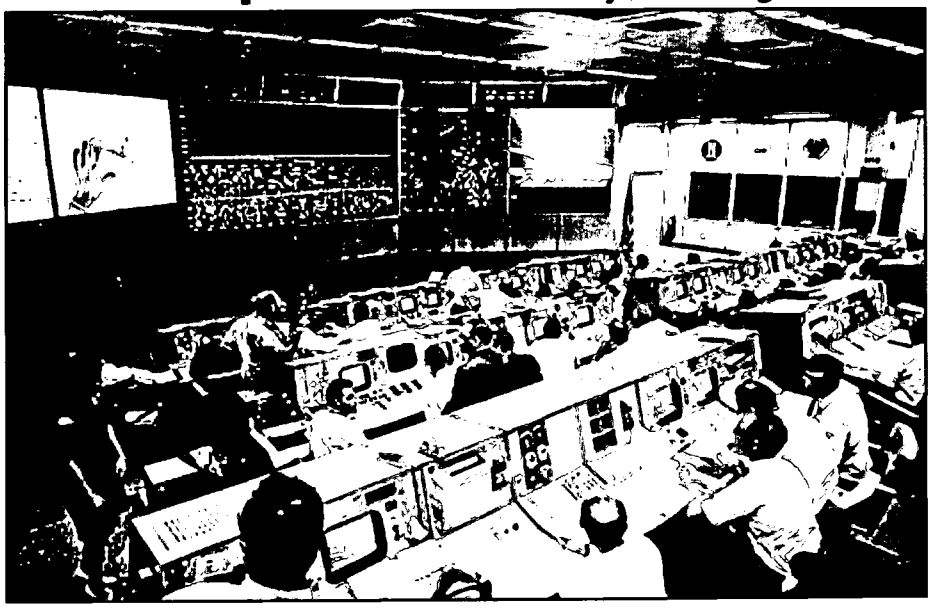
3. Although the roadway slopes slightly uphill, the rocket is being maintained in a vertical position. How and why do you think this was done?

4. Does seeing the people standing on the roadway in Photo 1 give you a better sense of the size of the height of the entire assembly than the measurement in Reading 2? Discuss.

5. How do you think that actually attending a launch like the one shown in Photo 2 would differ from seeing a photograph or a television image of it?

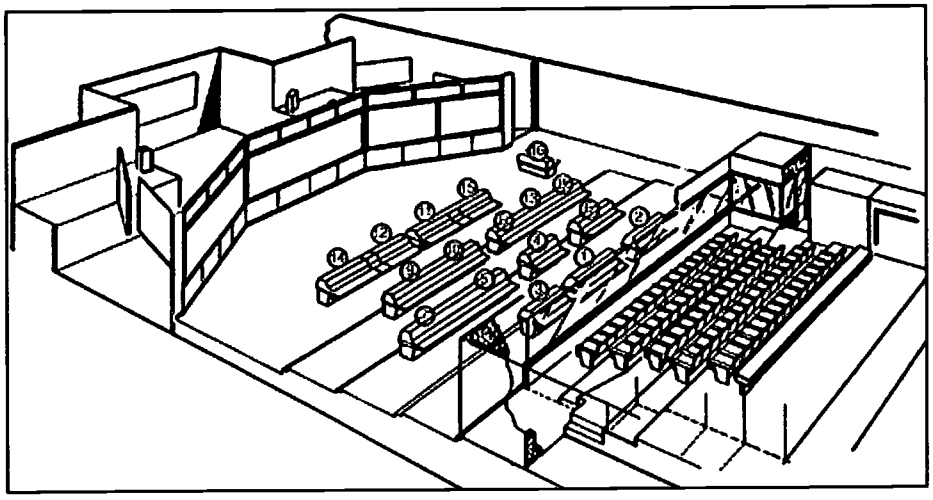
Visual Evidence

Photo 3: Mission Control Center, Manned Spacecraft Center (now Johnson Space Center), July 1969.



(National Aeronautics and Space Administration)

Illustration 1: Mission Control Center assignments.



(National Aeronautics and Space Administration)

Key to Illustration 1:
Assignments in the Mission Control Center, with their primary responsibilities.

Information is displayed on television monitors, indicator lights and digital readout devices on the consoles. Information is also displayed on the large group display projection screens at the front of the control room. A visitor viewing room, providing seating space for 74 persons, is located at the rear of the control room.

1. Mission Director--overall mission responsibility and control of flight test operations.
2. Department of Defense Representative--overall control of Department of Defense forces supporting the mission.
3. Public Affairs Officer--responsible for providing information on the mission status to the public.
4. Flight Director--responsible to the Operations Director for detailed control of the mission from liftoff until conclusion of the flight.
5. Assistant Flight Director.
6. Network Controller--detailed operations control of the Ground Operational Support System network.
7. Operations and Procedures Officer--responsible to the Flight Director for the detailed implementation of the Mission Control Center/Ground Operational Support Systems mission control procedures.
8. Vehicle Systems Engineers--monitor and evaluate the performance of all electrical, mechanical, and life support equipment aboard the spacecraft.
9. Flight Surgeon--directs all operational medical activities concerned with the mission, including the status of the flight crew.
10. Spacecraft Communicator--voice communications with the astronauts.
11. Flight Dynamics Officer--monitors and evaluates the flight parameters required to achieve a successful orbital flight; gives "Go" or "Abort" recommendations to the Flight Director.
12. Retrofire Officer--monitors impact prediction displays and is responsible for determination of retrofire times.
13. Guidance Officer--detects Stage I and Stage II slowrate deviations and other programmed events, verifies proper performance of the Gemini Inertial Guidance System, and recommends action to the Flight Director.
14. Booster Systems Engineer--monitors propellant tank pressurization systems and advises the flight crew and/or Flight Director of systems abnormalities.
15. Assistant Flight Dynamics Officer.
16. Maintenance and Operations Supervisor--responsible for the performance of Mission Control Center-Houston equipment.

Photo 3 and Illustration 1 (with its key) show the Mission Control Center at the Manned Spacecraft Center (Johnson Space Center) in Houston during the *Apollo 11* mission. There was also a mission control room at the Kennedy Space Center

that handled the launch until the rocket cleared the launch tower. The computers shown were extremely sophisticated electronic equipment in 1969; personal computers were not yet available.

Questions for Photo 3 and Illustration 1

1. Study Photo 3 carefully and make a list of everything you can see, both people and equipment. What are your impressions of what people are doing? Can you identify different activities that these people are engaged in? Why do you think there are so many people?

2. Study Illustration 1 and its key. The job descriptions are written in bureaucratic language. Take one job and describe in ordinary language what you think this person actually did. What kind of problem was the person you have selected expected to handle? When you have completed this exercise, list all the potential problems you and your classmates have identified on the board. Remember that each problem had to be anticipated and methods devised to either prevent or correct it if the mission was to succeed. Remember also that failure to solve these problems might lead to the deaths of the astronauts.

3. The large boards in the front of the room are projection screens where television images and other data could be displayed. Why do you think these large screens were necessary when everyone in the room seems to have his own computer?

4. The men in this room tracked every minute of the *Apollo* flight, from liftoff on July 16 to moon landing on July 20 to splashdown on July 24. How do you think they reacted when the large screens at the front of the room showed the pictures of Armstrong and Aldrin walking on the Moon?

5. Why do you think NASA provided space for visitors and reporters at Houston?

Visual Evidence

Photo 4: Front page of *The [Washington] Evening Star*, July 21, 1969.

The Evening Star — Apollo Edition

WASHINGTON, D. C., MONDAY, JULY 21, 1969—48 PAGES

Man Walks on Moon

'One Small Step . . . One Giant Leap'

AMERICAN ASTRONAUTS NEIL ARMSTRONG (RIGHT) AND EDWIN ALDRIN WALK ON THE MOON

(Copyright Washington Post. *Used with permission from the D.C. Public Library)*

Photo 4 shows a television image of the astronauts on the Moon that fills the whole front page of the newspaper. The largest television audience in history stayed up to see the landing, and views like this were published in newspapers and magazines worldwide.

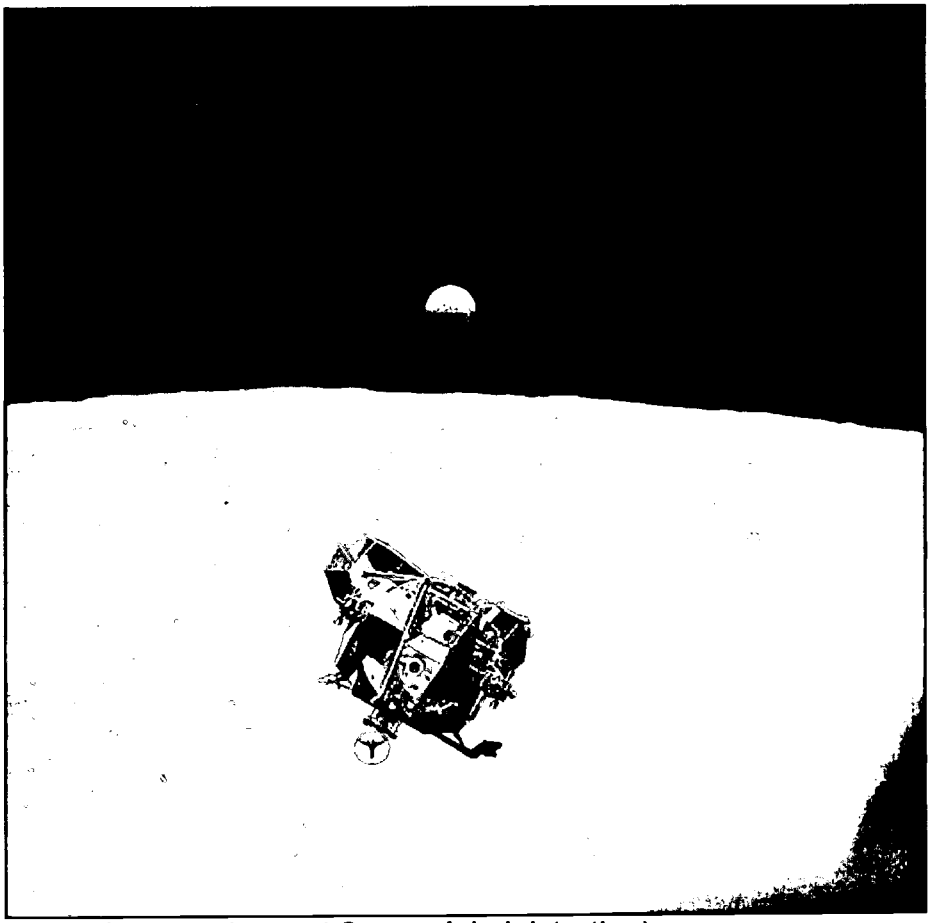
Questions for Photo 4

1. Why do you suppose there is so little writing on the front page of this paper? Do you think this was an effective use of the front page? Why or why not?

2. Many people kept copies of the newspapers that reported the landing on the Moon. Why do you think they did that?

Visual Evidence

Photo 5: View of the Earth from space.



(National Aeronautics and Space Administration)

Photo 5 shows the lunar module returning to the command module. The surface of the Moon is behind the lunar module, and the earth, half in shadow, is visible in the upper center of the photo.

Questions for Photos 5

1. For some astronauts, the view of the earth from the Moon was one of the most memorable parts of their space flights. Why do you think that might have been the case?

2. What can you learn about the lunar module from studying this photo? What can you learn about the Moon?

3. Many people think that images like this, showing the Earth as a small, fragile "blue marble," helped create the modern environmental movement. Do you agree or disagree? Why?

Putting It All Together

The following activities will help students apply what they have learned about the cooperative work that went into the successful *Apollo 11* mission.

Activity 1: Unexpected Benefits from Space Research

Explain to students that 2002 marks the 40th anniversary of the Technology Utilization Program. Under this program, NASA and scores of independent entrepreneurs have joined forces to produce tens of thousands of new products and processes using technologies originally developed for the space program. Ask students to refer to the NASA web site [http://www.nasa.gov/] to identify some of these "spin-offs." Ask students to identify products developed as a result of the space program that they use in their daily life. Ask them to consider why NASA might have established the Technology Utilization Program. What other scientific benefits have grown out of the program? Hold a class discussion about how you would measure the success of the Apollo program and whether it was worth the many millions of dollars invested in it.

Activity 2: A Mission to Mars?

Explain to students that in 1989, during the celebration of the 20th anniversary of the *Apollo 11* flight, President George Bush asserted: "Before the 50th anniversary of our first landing on the Moon, the American flag should be planted on Mars!" If this goal is to be met, humans will be landing on Mars by 2019.

Divide students into groups of four or five, with each group using all they have learned about the *Apollo 11* mission to make a list of what would be needed to plan a mission to Mars. Some topics to consider might include: research on Mars and space travel, design and manufacture of rockets, selection and training of astronauts, and life support and rescue.

Remind them that a Mars mission will be much more complicated than a trip to the Moon and back. It takes about three days to get to the Moon, but six months to a year will be needed to get to Mars. Radio signals make the round trip between the Earth and the Moon in 2.6 seconds, but it will take up to 41 minutes to exchange messages between the Earth and Mars. Astronauts on Mars will probably have to bring all of their own shelter, food, water, and breathable air with them.

There have already been many visits to explore the red planet, both from orbiting space crafts and from roving vehicles on the surface. Some students may want to study these missions and report back to the class about what they have revealed about conditions on Mars.

When the groups have completed their lists, have them combine their answers and then discuss the complexity and expense involved in developing a manned mission to Mars. Do they think the achievement would be worth the cost in money and the risk to human life? Would they like to be involved? Why or why not?

Activity 3: What Price History?

Tell the students that NASA signed a contract to demolish the launch tower shown on the right side of the *Saturn V* rocket in Photo 2 in 1983, so that they could modify the launch pad for the space shuttle. The demolition contractor was planning to sell the steel for scrap. Some people wanted the tower preserved for reassembly because of its association with the *Apollo 11* flight, even though it was only 20 years old. NASA opposed preserving the tower because of its cost, which might reach $4 million. In an article titled "What Price History?", published on March 13, 1983, in the *Orlando Sentinel*, Charlie Jean wrote that the tower...

is the Rembrandt's easel of the space age. It was the last Earthly foothold for Neil Armstrong, Ed Aldrin and Mike Collins before they thundered off to the Moon. It pointed the way for the Skylab astronauts, for the Apollo-Soyuz voyagers, and for fliers of less renowned missions in the Magellan age of space.

Ask the students to discuss the following questions: What are the arguments for preserving the *Apollo* launch tower? What are the arguments for dismantling it? What makes a place historic? Ask them whether they think the age of a place has anything to do with people's willingness to see it as historic. Why or why not? Ask them whether they think equipment like this should be preserved or modified for future space flights, saving millions of dollars? If they are preserved, who should pay the cost of preserving them?

Divide students into groups and have each group try to find a "place" (a building, a transportation system, a park or other natural area, etc.) in their community that is associated with an important event that has occurred in their or their parents' lifetimes. Ask each group to share what information they have gathered, and then have the class as a whole decide if any or all of the "places" should be considered "historic" and, if so, should they be preserved and/or interpreted for future generations.

Following the discussion you might want to tell the students that the launch tower was eventually dismantled and stored. Parts of it have been re-erected as part of an interpretive exhibit at the *Apollo/Saturn V* Center on the grounds of the Kennedy Space Center. Ask the students whether they think this was an appropriate way to deal with the tower.

America's Space Program: Exploring a New Frontier-- Supplementary Resources

After reading *America's Space Program: Exploring a New Frontier*, students will appreciate the cooperation that was needed to send a man to the Moon and bring him safely home. Students and educators who want to know more will find many useful resources on the World Wide Web.

NASA http://www.nasa.gov/

The NASA web site contains a wealth of information on the history of the space program and on current projects. It also includes a variety of photographs and educational materials relating to the Apollo mission.

Space Centers

The web sites for the Kennedy Space Center http://www-pao.ksc.nasa.gov/, the Marshall Space Flight Center http://history.msfc.nasa.gov/, and the Johnson Space Center http://www.jsc.nasa.gov/, all have useful material on the history of the centers, historic photos and documents, and educational material. The Kennedy Space Center site also provides information on viewing current launches.

The Apollo Program--National Air and Space Museum
http://www.nasm.edu/apollo/apollo.htm

The Apollo Program presents imagery & information from manned Apollo missions. This information comes from NASA and the National Air and Space Museum's Center for Earth and Planetary Studies Regional Planetary Image Facility collection.

National Park Service:The Historic American Buildings Survey/Historic American Engineering Record Collection
http://memory.loc.gov/ammem/hhquery.html

The Historic American Buildings Survey/Historic American Engineering Record Collection features documentation, photographs, and drawings of several space centers including the Marshall Space Flight Center in Alabama. Search on the key words "space centers."

National Park Service--Man in Space: Study of Alternatives
http://www.cr.nps.gov/history/online_books/butowsky3/index.htm

This planning study explores 26 significant sites associated with Man in Space. These sites include wind tunnels, rocket engine and development test facilities, launch complexes, training facilities, spacecraft and

hardware test facilities, mission control and tracking centers, and other support facilities throughout the United States. The study also discusses the 18 installations that played an important role in the early American space program and/or have value for interpreting the history of the program to the public. Other space museums and facilities that provide interpretive and educational opportunities related to the exploration of space are also briefly described.

National Park Service--Man in Space: Excerpts from a National Historic Landmark Theme Study
http://www.cr.nps.gov/history/online_books/butowsky4/index.htm
The Man in Space National Historic Landmark Theme Study evaluates all resources which relate to the theme of Man in Space and to recommend certain of those resources for designation as National Historic Landmarks. The Man in Space Theme Study considered resources relating to the following general subthemes:

A. Technical Foundations before 1958
B. The Effort to Land a Man on the Moon
C. The Exploration of the Planets and Solar System
D. The Role of Scientific and Communications Satellites

Space Movie Cinema http://vesuvius.jsc.nasa.gov/er/seh/movies
Made available by the NASA Johnson Space Center, Space Movie Cinema allows viewing of a number of short movies on space exploration on personal computers that have the necessary viewing capability.

To the Moon http://www.pbs.org/wgbh/nova/tothemoon/
To the Moon is a companion web site to the NOVA special that was shown on the Public Broadcasting System in 1999. It includes a panoramic view of the landscape of the Moon, science puzzles, and interviews with astronauts.

The Apollo Mode Decision
http://people.clemson.edu/~pammack/apmode.htm
The Apollo Mode Decision was developed by Pamela Mack at Clemson University, in part to demonstrate how Internet resources can be used for research. It provides a detailed analysis of the decision to use a lunar orbit mode to reach the Moon.

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